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Spectrophotometric Dating of Elliptical Galaxies in the Ultraviolet

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Abstract. The UV upturn phenomenon observed in elliptical galaxies is attractive for its potential value as an age indicator of old stellar systems. We present our most recent population models for the UV evolution of elliptical galaxies. We confirm that the dominant UV sources are either metal-poor or metal-rich hot horizontal-branch (HB) stars in local giant ellipticals, but we also note that the contribution from post-asymptotic-giant-branch (PAGB) stars overwhelms the UV spectrum at higher redshifts (look-back times). The model UV spectral energy distribution (SED) is therefore strongly affected by the current uncertainty of the mean mass of PAGB stars at higher redshifts. Fortunately, our models suggest that the far-UV observations at $z \geq 0.35$ could produce strong constraint on the PAGB mass, while observations at lower redshifts ($0.15 \leq z \leq 0.30$) would still provide constraints on the models on the origin of the UV upturn. Future observations of ellipticals from the *STIS/HST* and planned *GALEX* space UV facility will provide crucial database required for more concrete calibration of our UV dating techniques for old stellar systems.

1. Introduction

Recent observations on the origin of the UV upturn phenomenon of elliptical galaxies showed that hot HB and post-HB stars are the dominant UV sources in these systems (Ferguson et al. 1991; O'Connell et al. 1992; King et al. 1992; Bertola et al. 1995; Brown et al 1997). As demonstrated in our recent investigation (Yi et al. 1999), it is still not clear, however, whether the dominant UV sources are metal poor ("metal-poor HB model"; Lee 1994; Park & Lee 1997) or metal rich ("metal-rich HB model"; Bressan et al. 1994; Dorman et al 1995; Yi et al 1998). The "metal-poor HB model" suggests that the dominant UV sources are very old, hot metal-poor HB stars and their post-HB progeny, although metal-rich PAGB stars also contribute some UV flux. In this picture, nearby giant ellipticals are about 3 Gyr older than the Milky Way Galaxy, which would imply non-zero cosmological constant from time scale test. On the other hand, the "metal-rich HB model" suggests that the dominant UV sources are super metal-rich hot HB stars that experienced enhanced mass-loss and helium

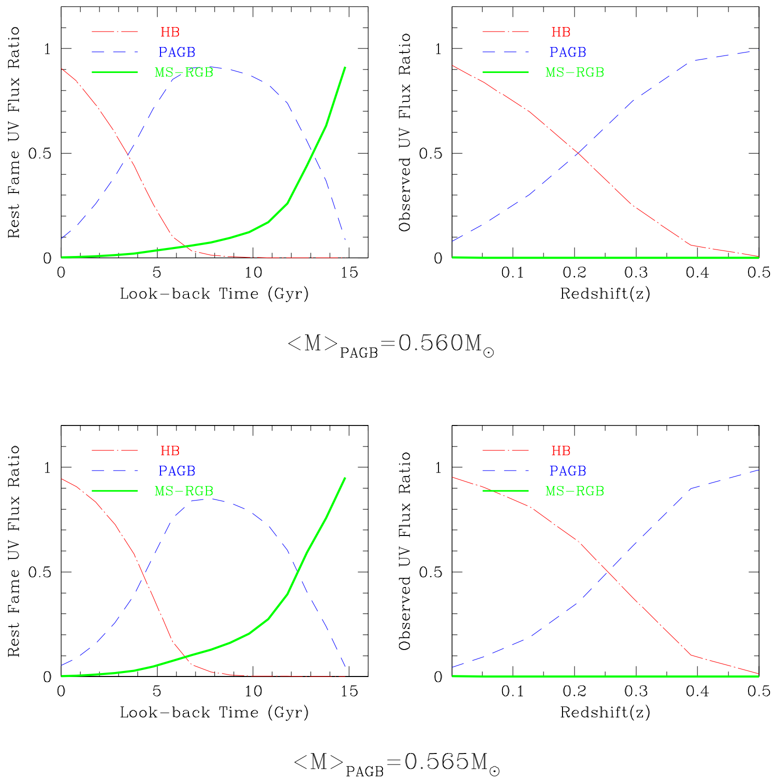

Figure 1. Contribution of the various evolutionary phases to the total UV flux (1500Å) of our models under "metal-poor HB solution", plotted as a function of look-back time (redshift). Note the variation of the dominant UV source with look-back time.

enrichment. If so, nearby giant ellipticals are similar in age to the Milky Way Galaxy, and there is no conflict with zero Λ cosmology from time scale test. Clearly, it is of considerable importance to understand the origin of the UV upturn. Considering this situation, we have recently investigated the evolution of UV flux with look-back time to see if two models predict substantially different evolutionary patterns. We found that this would indeed provide some strong observational test on the origin of the UV upturn phenomenon (Yi et al. 1999). The major uncertainty in these model calculations is the mass of PAGB stars, since it is only poorly constrained from direct observations. In this paper, we report our progress in investigating the effect of PAGB mass in the modeling of UV evolution of elliptical galaxies.

2. Variation of the Dominant UV source with Look-Back Tim

Our model calculations show that hot HB and post-HB stars contribute most of the UV light in nearby giant ellipticals (Fig. 1). As lookback time increses, however, PAGB stars are getting more dominat UV sources since the mean masses of helium burning stars are too high to be hot enough HB stars at younger

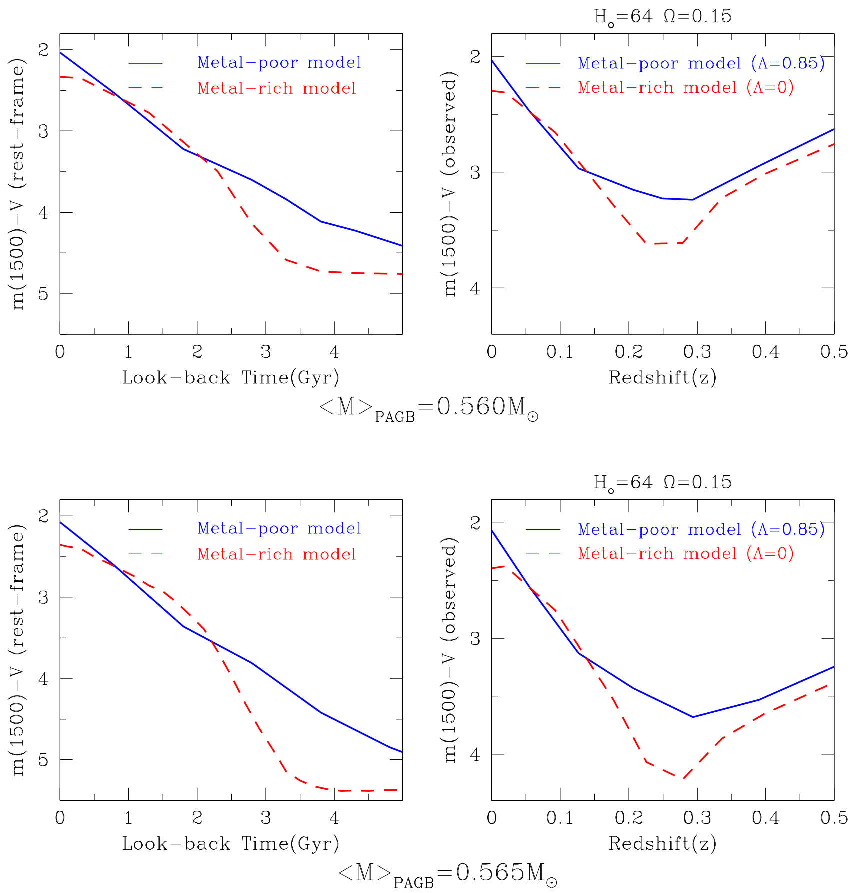

Figure 2. The evolution of 1500Å-V color index with look-back time & redshift both for the "metal-poor" and "metal-rich" models. Input parameters in all models are calibrated so that they reproduce the IUE UV flux of nearby giant ellipticals.

ages. (At very large look-back times, hot main sequence stars eventually become the major UV source.) Since the contribution from PAGB stars overwhelms the UV spectrum at higher redshifts, the model SED is strongly affected by the current uncertainty of the PAGB mass as look-back time increases.

3. 1500Å-V Color Evolution of Giant Elliptical Galaxies

We present, in Figure 2, the 1500Å-V color evolution of giant ellipticals predicted by both the "metal-poor" and "metal-rich" HB models under two assumptions regarding the PAGB mass. It is clear from Figure 2 that the 1500Å-V is not strongly affected by the uncertainty of the PAGB mass for the nearby giant ellipticals since the PAGB contribution to the total UV flux is less than 10%. PAGB treatment becomes significant, however, for the ellipticals at $z \geq 0.15$. Fortunately, both "metal-poor" and "metal-rich" models predict more or less the same 1500Å-V colors at $z \geq 0.35$, and thus far-UV observations at these redshifts (cf. Brown et al. 1998) would provide crucial constraint on the PAGB mass. Our models in Figure 2 suggest that the observations at lower redshifts ($0.15 \leq z \leq 0.30$) would still provide strong constraints on two models on the origin of the UV upturn. Future observations of ellipticals from the *STIS/HST* and planned *GALEX* (Martin et al 1998) space UV facility will provide crucial database required for more concrete calibration of our UV dating techniques for old stellar systems.

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